Techniques for Performing Tracheostomy

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Introduction

History of Tracheostomy
Percutaneous Tracheostomy
Techniques of Performing an Open or Surgical Tracheostomy
Percutaneous Dilational Tracheostomy
Choosing a Technique
Summary

One of the most commonly performed procedures in the critically ill, tracheostomy has been described and used for lifesaving treatment of upper-airway obstruction for at least 3,500 years. The procedure can be performed surgically in the operating room or at the bedside in the intensive care unit. Recently, percutaneous techniques performed by a variety of specialists have become popular alternatives to open surgical tracheostomy. Various devices have been developed to minimize identified risk and improve the simplicity of the procedure. These techniques and devices are described in this paper. Key words: tracheostomy, percutaneous, intensive care unit, surgical technique, medical devices. [Respir Care 2005;50(4):488–496. © 2005 Daedalus Enterprises]

Introduction

History of Tracheostomy

Besides being one of the most frequently performed procedures today, tracheostomy is one of the oldest described surgical procedures. It has been performed for over 3,500 years. Although it is not known when the first tracheostomy was actually placed, the procedure was probably performed by the ancient Egyptians. Possibly the earliest written descriptions are of tracheotomies performed in sheep, reported in the Babylonian Talmud and a similar account in the Rig Veda, the sacred Hindu book. The eminent Greek physician Galen credited Asclepiades with originating tracheostomy for the treatment of upper-airway obstruction due to pharyngeal inflammation in the 2nd century BC. Later physicians also performed the procedure, including Antyllus in the 2nd century AD. Successes were uncommon, and the procedure seems to have been abandoned in humans until the 1500s, when Brasavola (1546) reported a survivor. This patient was almost dead, suffering from an abscess of the windpipe; the operation was performed with a vertical incision and a tube was inserted.1

A major interest in tracheostomy developed during the 19th century, after Napoleon Bonaparte’s nephew died of diphtheria in 1807. Research into the technique occurred, with resurrection of some of the old instruments, and use of tracheostomy for treatment of airway obstruction for diphtheria became accepted. Bretonneau and Trousseau demonstrated and popularized the technique. At this time mortality from the procedure was considered acceptable if 25% of the patients survived.1

Chevalier Jackson standardized the indications for tracheostomy, the technique itself, and the instruments used,
around the turn of the 20th century. He developed anatomically correct tracheostomy tubes, recommended a “high” tracheostomy location (ring 2 or 3), and condemned cricothyroidotomy because of its high complication rate.\(^2\) He is considered the father of the surgical specialty of ear, nose, and throat surgery, which has recently been reborn as otorhinolaryngology/head-and-neck surgery.

**Percutaneous Tracheostomy**

Placement of a tracheostomy percutaneously is not a new idea; pictures of devices that appear to have been developed for this purpose date back to the middle ages. A modern percutaneous tracheostomy device was developed by Toy and Weinstein in 1969, and its use in 100 trauma patients was reported in 1986.\(^3\)\(^4\) The wire-guided percutaneous technique for percutaneous tracheostomy was developed and reported in the same year by the American surgeon, Ciaglia, who combined the Seldinger wire nephrostomy tube multiple-dilator placement technique with a special, low-profile tracheostomy tube.\(^5\) Several variants on the percutaneous tracheostomy technique have been developed, including a wire-guided sharp forceps (Griggs technique),\(^6\) performance of the procedure under bronchoscopic control, using a single, tapered dilator (Blue Rhino),\(^7\) passing the dilator from inside the trachea to the outside (Fantoni’s technique),\(^8\) and using a screw-like device to open the trachea wall (PercTwist).\(^9\) Each of these variations came about as an attempt to improve some aspect of another technique. The classical surgical approach and percutaneous techniques will be described in this paper.

**Techniques of Performing an Open or Surgical Tracheostomy**

Surgical tracheostomy (ST) is usually performed in the operating room on a patient under general anesthesia, but it may be performed at the bedside in the intensive care unit. Usually the airway has been secured by a cuffed endotracheal tube; however, patients with partially obstructing pharyngeal or laryngeal tumors may undergo tracheostomy with light (or no) sedation and local anesthesia. The patient’s shoulders are elevated with head extension (unless cervical disease or injury is present), elevating the larynx and exposing more of the upper trachea. Prophylactic antibiotics specific for skin pathogens should be administered 30–60 min prior to skin incision. The skin from the chin to below the clavicles is sterilely prepared. If excessive hair is present, it should be removed with electric clippers immediately prior to skin preparation. Sterile drapes are placed, creating an opening from the top of the larynx to the suprasternal notch.

Local anesthesia with a vasoconstrictor is usually infiltrated into the skin and deeper tissues to reduce the amount of bleeding during the procedure. The skin of the neck over the 2nd tracheal ring is identified, and a vertical incision about 2–3 cm in length is created. Care to avoid cutting deeper than the subcutaneous tissues must be exercised to avoid lacerating the thyroid isthmus or a large neck vein. Sharp dissection following the skin incision is used to cut across the platysma muscle, with bleeding controlled by hemostats and ties or electocautery. Blunt dissection parallel to the long axis of the trachea is then used to spread the submucosal tissues until the thyroid isthmus is identified (Fig. 1). If the gland lies superior to the 3rd tracheal ring, it can be bluntly undermined and retracted superiorly to gain access to the trachea. If the isthmus overlies the 2nd and 3rd ring of the trachea, it must be mobilized and either a small incision made to clear a space for the tracheostomy (Fig. 2) or complete
transection of the isthmus must be accomplished (Fig. 3). Blunt dissection is continued longitudinally through the pretracheal fascia, and the desired ring (usually the 2nd ring) is identified.

One of 2 types of tracheal entry is usually used for ST. These are: complete removal of the anterior part of one of the tracheal rings to create the stoma, and creation of a flap with the severed part of the ring. In the ring-removal approach, the ring is lifted with a tracheal hook and 2 circumferential sutures are placed around the ring laterally. The portion of ring between the secured sutures is then cut and removed, leaving a hole in the anterior tracheal wall for the tracheostomy tube. The sutures are left in place and used to provide counter traction on the trachea as the tube is forced into the lumen. This is illustrated in Figure 4. The ring sutures are cut long and left out of the wound or used to secure the tracheostomy tube. These sutures can be used to identify the trachea and reinsert an inadvertently dislodged tracheostomy tube. After placement of an ST, the
fistula tract is not stable for at least 4–5 days, and a tube dislodged soon after placement often cannot be reinserted through the fistula into the trachea. The ring sutures may help if this situation occurs.

A second method for entry into the trachea involves creating a tracheal wall flap sutured to the skin. This is done by incising the fascia over the superior ring and entering the trachea along its inferior margin. This becomes the outer lip of the flap. Lateral cuts through the lower ring complete the sharp dissection. The flap thus created is reflected downward and attached with several sutures to the skin of the neck. This is shown in Figure 5.10 This fistula is truly a “stoma,” with tracheal mucosa approximated to the skin. The stability of this tract is believed to be superior to the ring resection-removal technique; however, no study has convincingly demonstrated this.

**Percutaneous Dilational Tracheostomy**

As mentioned, an alternative to ST is percutaneous dilational tracheostomy (PDT), which has become a very common method of placing a tracheostomy in critically ill patients in the intensive care unit. It is rapid, simple, easy to learn, and cost-effective. While it seems superior to ST in some respects, some studies suggest a higher incidence of short-term but important problems. Long-term problems such as scar development, tracheal cutaneous fistula, and tracheal stenosis may be less with PDT, but more data will be needed to fully assess these risks.

There are several different methods of performing PDT, the most common is that of Ciaglia, in which a guide wire is placed between the first and second or second and third tracheal rings, and a series of stiff plastic dilators are sequentially forced into the tracheal wall over the guide wire.
until a stoma of sufficient size to accommodate the desired tracheostomy tube is created (Fig. 6). As with placement of an ST, a PDT is usually performed in an anesthetized patient, can be done in the intensive care unit or operating room, and requires neck extension and a sterile field. Whether prophylactic antibiotics are useful for PDT is not yet known; however, one report suggests that they should be used and be tailored to the known flora of the tracheobronchial tree.11,12

While some clinicians continue to perform PDT blindly, most have adopted a technique of observing and directing the needle and wire placement, using fiberoptic bronchoscopy.13 This may help prevent inadvertent injury of the membranous tracheal (posterior) wall or too lateral a location of the tracheostomy.14 In order to visualize the upper rings of the trachea with the bronchoscope, the endotracheal tube must be withdrawn until the tip is just in the larynx. This creates a substantial gas leak, as the cuff is no longer in the trachea. Patients experiencing severe hypoxic respiratory failure may deteriorate during this time and...
Patients requiring a tracheostomy only for airway access or protection often can have a laryngeal mask airway replace the endotracheal tube to provide the route for bronchoscopic visualization. The view of the larynx is unhampered when performed this way, making accurate identification of the tracheal rings easy. The bronchoscopic view of the wire being placed, seen in Figure 7, was obtained this way. In Figure 8 the dilator can be seen being passed over the wire. In addition to facilitating PDT, bronchoscopy through a laryngeal mask airway often reveals important pathology of the vocal cords (Fig. 9).

An alternative to the sequential dilator technique was developed by Griggs et al. Using a tracheal spreader modified to thread over the wire, this technique involves forceps dilation to create the skin path and tracheal stoma. As with the Ciaglia technique, the trachea is entered between...
the appropriate tracheal rings with an intravenous catheter (Fig. 10). Aspiration of air confirms tracheal entry. Bronchoscopy can also be used to prevent incorrect placement. The guide wire is threaded through the catheter (Fig. 11). The sharp-tipped dilating forceps (Fig. 12) are passed over the wire and spread in the skin and soft tissues of the neck (Fig. 13A) and into the trachea and spread again (see Fig. 13B). A tracheostomy tube is placed over the guide wire and through the passage created. Tracheal injury may be higher with this technique (especially if performed without bronchoscopy) than the other PDT techniques.

The Blue Rhino dilator is a single, tapered dilator that is used instead of the sequential dilators of Ciaglia (Fig. 14). It has a slippery coating that makes insertion very easy. It is softer and therefore (probably) less likely to damage the membranous tracheal wall. Since there is only a single dilator to pass, insertion is more rapid.

A substantial amount of force is needed to insert the dilators and tracheostomy tube, which often collapses the trachea and fractures a tracheal ring. The importance of ring fracture is not known. In an attempt to prevent membranous tracheal (posterior) wall injury and protect the anterior rings from fracture, Fantoni devised a special dilating tube that is placed translaryngeally through the trachea and pulled out rather than forced in. The technique, illustrated in Figures 15–17, is complicated and there are mixed reports regarding its success at protecting the trachea.

Another attempt to solve the excessive-force problem with PDT is the PercTwist, a screw-action dilator that was designed to allow dilation with twisting while lifting the trachea rather than pushing down (Fig. 18). Reports with this method are preliminary and few.

Choosing a Technique

The determining factors in deciding whether to use an ST or PDT in a particular situation include available resources (are there experienced clinicians available for either technique?) and patient factors. While there are no hard rules, some reasonable guidelines might include:
1. Coagulation abnormalities favor ST over PDT, since bleeding vessels are more easily controlled under direct vision. Limits on “how abnormal” should be in line with those set for other invasive procedures.

2. High levels of support need for oxygenation would favor ST over PDT (ie, fraction of inspired oxygen ≥ 0.7 and positive end-expiratory pressure ≥ 10 mm Hg have been suggested).

3. Patients with unstable or fragile cervical spines would favor ST over PDT.

4. Patients having recent surgical repair of neck injuries may benefit from PDT because of its lower wound-infection rate.

5. Patients with “unfavorable” neck anatomy would favor ST over PDT (ie, previous surgery, neck masses, poor neck mobility, or obesity may be more complicated for PDT).

Summary

ST has been performed for thousands of years to relieve upper airway obstruction; however, only in the past 200 years has survival of the operation been adequate to recommend its use. Currently, tracheostomy is performed in many situations and in critically ill patients with low morbidity. New percutaneous techniques offer advantages over standard open ST. However, operator experience and individual patient issues should control which technique is employed. PDT techniques are evolving and improving with time.

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REFERENCES

TECHNIQUES FOR PERFORMING TRACHEOSTOMY


EMERGENCY TRACHEOTOMIC SET